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Forest Health Protection
Pacific Southwest Region

Date: June 14, 2005
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To: District Ranger, Big Valley Ranger District, Modoc National Forest

Subject: Biological evaluation of stands for silvicultural certification for John Landoski.

John Landoski, Culturist, Big Valley Ranger District, Modoc National Forest, requested a field evaluation by Forest Health Protection of two stands he is writing prescriptions for as part of the requirement for silvicultural certification. Bill Woodruff, Plant Pathologist and Sheri Smith, Supervisory Entomologist, visited the stands with John on May 19, 2005. The objective of the field visit were to 1) determine if any insect or disease caused tree decline or mortality existed in the stands, 2) assess the current conditions with respect to tree health and susceptibility to insects or diseases, and 3) discuss the potential impacts of insects and diseases on stand management objectives.

Stand Descriptions
Stand 4260120

This is a 16 acre eastside pine stand located within the Rush Creek wildland-urban interface (WUI). It is comprised of ponderosa pine, Jeffrey pine and western juniper, with Jeffrey pine dominating the composition. The long-term average annual precipitation in the area is 20 inches. The site is a Meyers 80 and has a current stocking level of 136 square feet of basal area/acre and stand density index (SDI) of 233. Tree sizes range from 1 to 39 inches diameter at breast height (DBH). There are about 180 trees per acre with 75% of these being less than 13 inches DBH. The majority of trees are between 50 - 120 years old, with the exception of three trees/acre that are greater than 30 inches DBH and over 250 years old. There is less variation in tree ages than might be expected with the diameter range of the trees in the stand. For example, trees between 5-7 inches DBH average 92 years of age compared to trees between 15-28 inches DBH that range in age between 107-120 years.

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Based on the NEPA decision, the stand is to be managed for 1) healthy forest conditions; 2) to provide outputs to meet the objectives of the Big Valley Sustained Yield Unit (BVSYU) and 3) to restore conditions that are resilient for fire. The stand is along Highway 299 located in an area designated as partial retention and is to be managed as even-aged. There have not been any contemporary stand management activities.

Stand 4270400

This is a 120 acre eastside pine stand also located within the Rush Creek WUI. This stand is dominated by ponderosa pine and incense cedar with a lesser component of western juniper, Jeffrey pine, black oak and white fir, in descending order of contribution to species composition. The site is a Meyers 70 and has a current stocking level of 155 square feet of basal area/acre and a SDI of 328. Tree size ranges from 1 to 33 inches diameter at breast height (DBH). There are about 600 trees per acre with 70% of these being less than 7 inches DBH. Tree ages range from around 50 years old for trees less than 3 inches DBH to 249 years for trees in the 27 - 29 inch DBH class.

The management objectives, based on the NEPA decision, are the same as those specified above for Stand 4260120. A portion of this stand borders Highway 299 and is designated for retention with the remaining portion designated as partial retention. This stand is to be managed for old growth emphasis, defined in the Modoc National Forest Land Management Plan (1991) as having medium to large trees (>24 inches DBH), greater than 40% canopy cover and tree ages between 190 to 270 years. Past stand management activities include a timber sale in 1964.

Field Observations

Both stands have some ponderosa pines (a few 3-5 tree group kills) that were attacked during 2003 and 2004 by western pine beetle, *Dendroctonus brevicomis*, and mountain pine beetle, *Dendroctonus ponderosae*. Stand 4260120 had a few pine trees under current attack by red turpentine beetle, *Dendroctonus valens*. These trees were located on the edge of an older pocket of tree mortality. Stand 4270400 also has a few Jeffrey pine trees that were attacked by Jeffrey pine beetle, *Dendroctonus jeffreyi*. Many of the dead trees had pouch fungus, *Cryptoporus volvatus*, conks on them. Pockets of down and dead trees resulting from mortality that occurred several years ago were also observed in both stands. Groups of older dead trees were more prevalent in Stand 4270400. A few of the large diameter, old growth pines in Stand 4260120 were killed several years ago by bark beetles. Tree decline/death caused by root diseases was not observed in either stand.

Discussion

The recent and older pine mortality caused by western, mountain and Jeffrey pine beetles can be attributed to moisture stress, overstocking, and elevated bark beetle activity. It is likely the older group kills were created during the drought period that extended from 1987 – 1994. The more recent bark beetle activity occurred during a drought period which extended for four years prior to 2005. Historically, the most significant effect on forests in California has been conifer mortality caused by bark beetles during drought periods. Conifer mortality tends to increase whenever annual precipitation is less than about 80% of the long term average. Trees

stressed by inadequate moisture levels have their defense systems weakened to the point that they are highly susceptible to attack by bark, engraver and wood-boring beetles. Inadequate moisture levels combined with overstocked stands often leads to unacceptable levels of conifer mortality.

Bark and engraver beetle-related mortality occurs primarily in small groups of trees. Successful attacks almost always result in tree mortality. In general, mortality occurs in overstocked stands, however, during periods of protracted drought, an increase in the level of mortality may be expected to occur throughout various stocking regimes. Effects and impacts resulting from bark beetles may include but are not limited to the following: individual tree mortality, openings that vary in size, less trees per acre, reduced canopy closure, an increase in standing dead and down woody material, an increase in fuel load, an increase in decomposition and nutrient cycling, increase species diversity/decrease species diversity, increase in snags and cavity nesting opportunities and a change in species composition. The importance or significance of these effects and impacts depends on their severity and extent and how they affect (positively and/or negatively) ecosystem structure and function and specific management goals and objectives.

Management activities that promote tree health and vigor also reduce the susceptibility to bark beetle-related mortality. Thinning is the most effective silvicultural treatment available to restore conifer health. Thinning from below reduces flammable fuels and creates growing space for trees. In addition, opening up pine stands may limit the ability of bark beetle pheromones to concentrate in a single location after an initial attack, thus decreasing the likelihood of bark beetles attacking groups of trees. Following thinning, mortality would continue to occur and fluctuate in response to the amount of available moisture, but at levels that would more closely approximate naturally occurring levels mortality. Nutrient cycling and the creation of snags and down woody material would also occur at more natural levels.

Improving growing conditions should result in reduced mortality of large diameter trees and an increase in mid-diameter trees available to grow into large diameter classes. Silvicultural prescriptions can be developed to meet the overall objectives of maintaining tree health throughout the project area, but these may be contrary to the objectives in retention areas. Forest health restoration activities should take an ecological approach to multiple-use management. Objectives should include: 1) restoring the resistance and resilience to natural stresses; 2) decreasing the risk of catastrophic fires; and 3) modifying the vegetation to reduce/limit the amount of tree mortality caused by insects and diseases to acceptable levels dependent upon management objectives.

In Stand 4270400, the ability to manage for old growth emphasis in the east side pine may be limited by the 40% crown closure requirement. Currently, less than 2% of the trees per acre are in the desired age 190 – 270 year age class. The remaining 98% are between 50 and 120 years old. To keep the few large trees on the site alive, radial thinning that would remove competing vegetation at least to the drip line should be considered. Older, more slowly growing trees are very susceptible to bark beetle attack, so reducing competition is extremely important. One hundred twenty years ago, it appears that the few large trees in Stand 4270400 had no trees competing with them, so they were able to survive. To recruit more trees into the older age classes and larger diameters, a level of thinning that would greatly improve tree growth and vigor

should be considered. Many of the smaller trees have been suppressed for an extended period of time and their ability to respond to thinning maybe less or may take a longer period of time compared to open grown trees. In addition, the susceptibility of the white fir in Stand 4270400 to fir engraver, *Scolytus ventralis*, caused mortality is extremely high. The long-term average precipitation is this area is 20 inches per year. This level of precipitation is insufficient to grow white fir over the long-term. Prolonged drought will result in high levels of white fir mortality, so this species should be selected against when thinning. Over all, managing for fewer, healthy, vigourous and more drought tolerant residual trees may be a more realistic management objective than attempting to maintain/promote conditions that are conducive to "group kills" by bark beetles in the future.

For ponderosa pine stands in northern California a SDI of 230 defines a threshold at which bark beetle begin to kill a few trees but net growth is still positive (Oliver and Uzoh, 1977). These authors also found that the limiting SDI as defined by *Dendroctonus* bark beetles is 365. In their work, ponderosa pine stands that approached an SDI of 365 usually suffered large losses from bark beetles. Their only data for Jeffrey pine stands was collected in plantations that did not have any bark beetle activity. Since Jeffrey pine beetle was found in Stand 4270400, it is reasonable to use the same SDI thresholds as those used for ponderosa pine stands with bark beetle activity. The SDI for Stand 4260120 and Stand 4270400 is 233 and 328, respectively. Both stands have exceeded the threshold of imminent mortality and Stand 2470400 is approaching the level where high levels of mortality can be expected. Taking into account whatever the desired re-entry period is and annual growth, thinning stands to an SDI such that they would not greatly exceed 230 prior to the next entry should limit unacceptable levels of bark beetle caused mortality.

Prescribed fire

Historically, natural fire kept the understory trees in these stands at much lower densities. With fire exclusion over the last century, many understory trees have become established. These additional trees are competing with each other and the few old growth conifers for a limited amount of moisture and light. After thinning, fire may be used to maintain lower tree densities. Underburning can damage some residual trees to the extent that they become more susceptible to bark beetle attacks. Trees that receive cambium and/or foliage damage may be at increased risk to bark and/or engraver beetle attack until they recover their vigor. In the absence of fire, excess duff has accumulated around the large, old trees in these stands. It may be necessary to remove this accumulated duff from around these trees prior to burning to limit cambium kill and subsequent tree mortality.

Slash management

To limit infestations by *Ips pini* beetles, pine slash greater than 3 inches in diameter should be removed from the site. Any whole green pine trees or pine slash should be removed within 30-45 days of creation during the summer field season if possible. If this is not possible, the slash and residual trees should be occasionally examined for beetle activity. *Ips* beetles may: 1) attack the residual trees concurrent with attacks made in the slash; or 2) beetle populations can first

develop in the slash and later emerge and attack the residual trees. The likelihood of successful attack in residual trees is lower in non-drought years.

Stump treatment

Root disease caused by *Heterobasidion annosum* can occur in this area. For this reason, it is recommended to treat freshly-cut conifer stumps with Sporax®, the registered borax product that has been shown to effectively prevent *H. annosum* spores from infecting conifer roots after entry through freshly cut stumps. A detailed description of annosus root disease management is found in the Region 5 Supplement to Forest Service Handbook 3409.11-94-1, Chapter 60.

If you have any questions or need additional information please contact us via phone or email.

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Additional information on Insects and Diseases

Western pine beetle, *Dendrotonus brevicomis*

The western pine beetle has been intensively studied and has proven to be an important factor in the ecology and management of ponderosa pine throughout the range of this host species. This insect breeds in the main bole of living ponderosa pines larger than about 4 inches DBH. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe, or fire injury. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latitude and elevation, there can be from one to four generations per year.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In California, drought stress may be the key condition influencing outbreaks in that healthy trees undergo sudden and severe moisture stress which can facilitate the buildup of western pine beetle populations. The thick, nutritious phloem and inner bark becomes host material for attacking beetles. Healthy trees ordinarily produce abundant amounts of resin, which "pitches out" beetles, however, when deprived of moisture, stressed trees cannot produce sufficient resin flow to resist attack. Any condition that results in excessive demand for moisture, such as tree crowding, competing vegetation, or protracted drought periods; or any condition that reduces that ability of the roots to supply water to the tree, such as mechanical damage, root disease, or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers, predaceous beetles and low winter temperatures are natural control agents.

Normal attack and development occur only in ponderosa and Coulter pine. Pitch tubes, ¼ to ½ inch in diameter, formed on the tree trunk around entry holes made by attacking female beetles are usually the first evidence of infestation. The pitch tubes are white to red-brown masses of resin and boring dust found in the crevices between the bark plates. Attacking adult beetles carry spores of a blue-staining fungus, *Ceratocystis minor* in special pouch-like structures in their heads called mycangia. As the beetles chew their way through the bark, the spores of this wilt-causing fungus dislodge and begin to germinate. In trees attacked in early or midsummer, it takes only a few weeks for the fungus to invade and block the conductive vessels of the inner bark and sapwood.

Western pine beetles pass through the egg, larval, pupal, and adult stages during a life cycle that varies in length from about 2 months in warm weather to 10 months in cool weather. All stages are completed beneath or in the bark of infested trees, except for a brief period when the adults fly to find new trees to attack. During an attack period, which may last 3 weeks, each female lays about 60 tiny pearl-white eggs individually in niches cut into the sides of the egg gallery. Some of these parent females may emerge and reattack to establish additional galleries elsewhere in the same tree or in other host trees. After incubating from 1 to 2 weeks, the eggs hatch. The larvae are small white grubs that feed first in the phloem, where they construct a short gallery. They then mine into the middle bark where most of their development takes place. After completing four larval stages, they transform into pupae and then into adults.

When beetles successfully attack a tree, they release minute amounts of behavioral chemicals into the air. These pheromones attract males and other females to the tree, causing a mass attack that tends to overcome the tree's natural resistance. Besides attracting western pine beetles themselves, the pheromones also attract their natural enemies, such as predaceous checkered and ostomid beetles. The ability of these beetles to sense the pheromones makes them effective predators during the critical attack phase.

To feed on a western pine beetle brood, woodpeckers have stripped off the outer bark of the tree, exposing the bright-orange inner bark.

Sinuous egg galleries characteristics of the western pine beetle in ponderosa and Coulter pine.

Information and photo source:
DeMars Jr., Clarence J. and Roettgering, Bruce H. 1982 . Western pine beetle. Forest & Insect Disease Leaflet 1. U.S. Department of Agriculture, Forest Service. 11 p.

Jeffrey Pine Beetle, *Dendroctonus jeffreyi*

The Jeffrey pine beetle is the principle bark beetle found attacking Jeffrey pine, which is its only host. It is a native insect occurring from southwestern Oregon southward through California and western Nevada to northern Mexico. The beetle normally breeds in slow-growing, stressed trees. The beetles prefer trees which are large, mature, and occur singly rather than in groups. When an epidemic occurs, the beetle may attack and kill trees greater than 4 inches in diameter regardless of vigor. Often the beetle infests lightning-struck or wind-thrown trees, but does not typically breed in slash.

Presence of the beetle is usually detected when the foliage changes color. The color change of the foliage is related to the destruction of the cambium layer by the beetle. Generally, the top of the crown begins to fade in a slow sequence, with the needles turning from greenish yellow, to sorrel, and finally to reddish brown. By the time the tree is reddish brown, the beetles have usually emerged from the tree. Another sign of beetle attack is medium size, reddish pitch tubes. Jeffrey pine beetles have a distinctive "J" shape egg gallery pattern on the inner bark. Larval mines extend across the grain and end in open, oval-shaped pupal cells.

The Jeffrey pine beetle is one of the larger pine bark beetles in California. The beetle has 4 life stages, egg, larva, pupa, and adult. The adults are stout, cylindrical, black, and approximately five-sixteenths of an inch long when mature. The egg is oval and pearly-white. The larva is white, legless, and has a yellow head. The pupa is also white and is slightly smaller than the mature larva. The life cycle is normally completed in one year in the northern part of the range, but in the southern part, two generations per year may occur. The principle period of attack is in June and July, but attacks also are frequent in late September and early October. Similar to other *Dendroctonus* species, Jeffrey pine beetles use pheromones that attract other beetles to a tree, causing a mass attack that tends to overcome the tree's natural resistance. Blue stain fungi are associated with Jeffrey pine beetle attacks and aid in overcoming the tree.

Normally the Jeffrey pine beetle is kept in check by its natural enemies, climatic factors, and host resistance. Similar to other *Dendroctonus* species, the availability of suitable host material is a key factor influencing outbreaks. Healthy trees ordinarily produce abundant amounts of resin, which pitches out attacking beetles. When deprived of moisture, trees cannot produce sufficient resin flow and they become susceptible to successful beetle attacks.

Jeffrey pine beetle adult galler with larval galleries braching off to the sides.

Jeffrey pine beetle larva creating a chamber to pupate in.

Mountain Pine Beetle, *Dendroctonus ponderosae*

The mountain pine beetle attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 4 inches DBH. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in sugra pines at lower elevations. Attacks can extend from the root collar up to near the top of the bole. Pheromones released during a successful attack may attract enough beetles to result in a group kill. Pitch tubes and red boring dust in bark crevices or on the ground indicate successful attacks. The adults bore long vertical egg galleries and lay eggs in niches along the sides of the gallery. A "J"-hook, similar to the gallery of Jeffrey pine beetle, is

common at the lower end of the gallery. The hatching larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults. The sapwood of successfully attacked trees is usually heavily bluestained. The bluestain fungi aid in overcoming the defenses of the host tree.

Natural factors affecting the abundance of the mountain pine beetle include low winter temperatures, nematodes, woodpeckers and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases, or drought, the effectiveness of natural controls decrease and tree mortality increases.

Exit holes, about 3/32 inch in diameter, made by mountain pine beetles.

Sapwood has been discolored by blue-staining fungi; heartwood is not stained.

Information and photo source:
Amman, Gene, D., McGregor, Mark D., Dolph Jr., Robert E. 1990. Mountain pine beetle. Forest & Insect Disease Leaflet 2. U.S. Department of Agriculture, Forest Service. 13 p.

Red turpentine beetle, *Dendroctonus valens*

The red turpentine beetle occurs throughout California and can breed in all species of pines. It normally attacks injured, weakened or dying trees and freshly cut stumps. The adults are attracted by fresh pine resin. They often attack wounded trees, trees scorched by wildfire or prescribed burns, lightning-struck trees or trees with root disease.

Attacks usually occur at the soil line or root crown and are characterized by a large reddish pitch tube at the point of entry. On severely stressed trees or during periods of drought, attacks may occur underground on the main roots up to 6 feet from the bole and also on the bole to a height of about 10 feet. If an attack is successful, the adults excavate an irregular gallery in the cambium and the female lays eggs along the sides. The larvae feed in a mass and destroy an area of cambium ranging from 0.1 to 1.0 square feet. Attacks do not always kill trees but may predispose them to attack by other bark beetles. Repeated or extensive attacks by the red turpentine beetle can kill pines.

Red turpentine beetle larvae.

Red turpentine beetle pitch tubes.

Fir Engraver, *Scolytus ventralis*

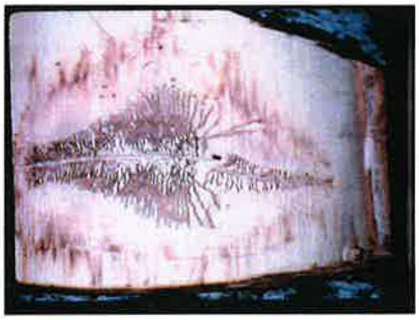
The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4 inches DBH are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without first killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium has been killed.

Fir engravers bore entrance holes along the main stem, usually in areas that are greater than 4 inches in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate successful attack or subsequent tree mortality. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack or are killed in the pitch. Pitch tubes formed by bark beetles attacks on pines are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or all of the bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry a brown staining fungi, *Trichosporium symbioticum*, into the tree which causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those which have little or no resistance to attack. Populations of less aggressive species of tree attacking beetles like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality however attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in the control of populations at endemic levels.



Fr engraver parent gallery (horizontal) and larval galleries (vertical).

Pouch Fungus, *Cryptoporus volvatus*

The pouch fungus causes a grayish, white rot of the sapwood of most conifers in western North America. For the most part, it occurs only on dead trees and snags within one to two years after the tree's death. The small, leathery, white fruiting bodies are produced in abundance within a short time after the tree is attacked. One of their distinguishing features is the lower spore-bearing surface that is covered by the fungus sheath except for a single hole through which insects enter, feed, and then exit and move on to spread the fungus. This unique adaptation to spread by the beetles and other insects accounts for how rapidily it can invade dead and dying trees.

Sporocarp of the pouch fungus, *Cryptoporus volvatus*